

# Underwater information display using aerial imaging by retro-reflection (AIRR)

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## 1. Introduction

In recent years, aerial display has been attracting attention. Aerial imaging by retro-reflection (AIRR) [1] has been proposed to form aerial information screen. By realizing the water information display, it is expected to be useful for ethology research on aquatic organism. In this study, we propose a method to form information screen under water by utilizing AIRR.

## 2. Principle of underwater imaging

Optical setups for AIRR are shown in Fig. 1. A part of light from the conventional display is reflected by the half mirror. Then, the reflected light reversely travels after it is reflected on the retro-reflector. A part of the reflected light transmits through the half mirror and forms the aerial image of the conventional display. AIRR features wide viewing angle and large display area with a low cost. Challenges of AIRR are to improve the brightness and resolution.

Our new optical setups for underwater information display by AIRR are shown in Fig 2. Light from the light source is reflected by the water surface and reflected light is returned to the original by the retroreflective sheet. Part of the light reflected by the surface of the water returns to the light source. Some of the light is condensed in the water passes through. In this principle, the light between the different refractive indices of air and water and acrylic medium passes. Condensed position by the refractive does not become the light source and symmetrically with respect to the reflecting surface is focused at a position above the position where a conventional aerial image is formed. The optical arrangement is not the only used in this experiment. In this experiment, also performs conventional method using a half mirror and method using surface reflection of the water. In this study, we carried out underwater imaging using three different methods.

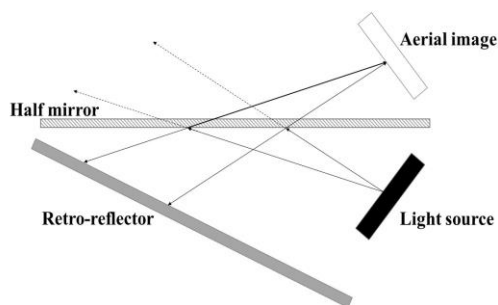


Fig. 1. Principle of aerial imaging by retro-reflection (AIRR).

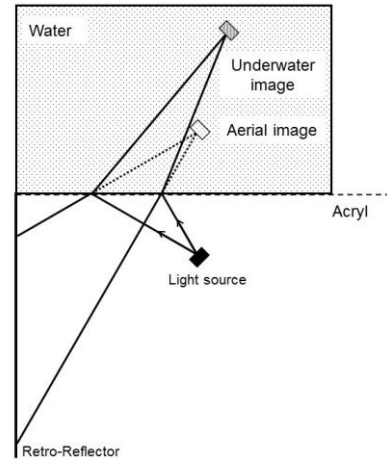


Fig. 2. Principle of underwater imaging by AIRR.

## 3. Result

The state of forming the underwater imaging by using a retro-reflection (AIRR) is shown in Fig. 3. Real image of a light source has been successfully formed next to the finger that is in the water in the photograph. Thus, we have confirmed that it is possible to form a real image under water by aerial imaging by retro-reflection.



Fig. 3. Result of underwater image by AIRR.

## 4. Conclusion

We have realized an underwater information display using a technique of forming the aerial image using a retroreflective (AIRR). It was mentioned to achieve a clearer underwater image as the future and challenges.

## References

- [1] H. Yamamoto, Y. Tomiyama, and S. Suyama, "Floating aerial LED signage based on aerial imaging by retro-reflection (AIRR)," *Optics Express*, vol. 22, No. 22, 26919-26924 (2014).